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Invention: MEDIA IDENTIFICATION FOR MAGNETIC TAPE DRIVE

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SPECIFICATION

MEDIA IDENTIFICATION FOR MAGNETIC TAPE DRIVE

BACKGROUND

[0001] This application is a continuation-in-part of United States Patent Application Serial No. 09/263,833, filed March 8, 1999, which is incorporated herein by reference in its entirety.

[0002] FIELD OF THE INVENTION

[0003] The present invention pertains to magnetic tape which is used for transducing information, and particularly to identification of magnetic tape cartridges.

[0004] RELATED ART AND OTHER CONSIDERATIONS

[0005] For decades information has been stored on magnetic tape medium using tape drives. Initially the magnetic tapes were wound about large reels in similar manner as film for early film projectors. In more recent years the magnetic tape has typically been housed in a cartridge or cassette, extending internally in the cartridge from a supply reel to a take-up reel. In some systems, the magnetic tape has longitudinal tracks recorded thereon (e.g., tracks that extend along the major length dimension of the tape). In other systems, the path of the magnetic tape is such that the tape is at least partially wrapped around a drum in a manner to transduce helical stripes or tracks on the magnetic tape. Some of the cartridges have a lid or the like which is displaced upon insertion of the cartridge into the tape drive, thereby exposing the magnetic tape to operative elements of the tape drive (e.g., tape guides, tape transport mechanisms, and transducing elements). Other cartridges are fabricated with a window or the like into which operative elements of the tape drive extend when the cartridge is loaded into the tape drive.

[0006] Some magnetic tape/cartridge manufacturers have developed techniques whereby, upon insertion into a tape drive, the tape/cartridge is identified as being of a certain type. For example, Minnesota Mining and Manufacturing Company (3M) has developed a pattern of holes formed in a tape which are optically detected as an indication that the tape is a quarter inch cartridge (QIC) tape. Similarly, Sony Corporation has a DDS pattern for 4 millimeter digital audio tape (DAT) identification, and a RS pattern for 8 millimeter MP identification (MP refers to metal particle coating type tape).

[0007] Debris and dust can collect internally in tape drives and eventually on magnetic tape itself. The presence of such debris or dust on the tranducing element(s), either by contact with the tape or otherwise, can lead to degredation of signal quality and thus decreased performance of the transducing element(s) and the tape drive overall. To counteract the problem of debris or dust aggregating on the tranducing element(s), typically periodically a cleaning cartridge is loaded into the tape drive. The cleaning cartridge resembles a tape cartridge in most aspects, but the media extending from the supply reel to the take-up reel is a cleaning material rather than magnetic tape. The cleaning material comprising the media is transported past the tranducing element(s) in a manner to wipe gently the tranducing element(s), thereby removing dust and debris. US Patent 5,369,285 to Georgis provides optical detection of cleaning medium in an information storage drive.

[0008] It has been know to combine both magnetic tape and some the of cleaning material on the same media. For example, US Patent 4,422,119 to Kawakami et al. forms at least part of a leader for magnetic tape with an abrasive cleaning material. US Patent 5,638,236 to Scott discloses tape having a first (preferably magnetic) portion with a cleaning leader directly spliced thereto. US Patent 4,893,209 to Siddiq provides multifunction cleaning tape that also has a segment for providing diagnositic/instructional information to a user.

[0009] What is needed, and an object of the present invention, is a magnetic tape that provides both cleaning and self-identifying capabilities.

[00010] BRIEF SUMMARY OF THE INVENTION

[00011] Media for use in a magnetic tape drive has an identification window segment having an electromagnetic transmissiveness which varies along at least a portion of its length in a manner chosen to provide a predetermined media or cartridge signature when the media is transported at a selected linear velocity. Preferably, the identification window segment is situated between essentially contrasting (e.g., opaque) sections of the media, such as magnetic recording/reproducing segment and a cleaning segment.

[00012] Upon insertion into a magnetic tape drive, the magnetic tape is transported past a detector assembly which directs a beam of electromagnetic radiation through the tape. Transport of the identification window segment past the detector assembly thus results in generation of a signal having a waveform with an amplitude which varies in accordance with the varying electromagnetic transmissiveness of the window. The signal is received at a processor, which uses the waveform of the signal to determine the type of the tape/cartridge and optionally to operate the tape drive in accordance with the thusly discerned type.

[00013] BRIEF DESCRIPTION OF THE DRAWINGS

[00014] The foregoing and other objects, features, and advantages of the invention will be apparent from the following more particular description of preferred embodiments as illustrated in the accompanying drawings in which reference characters refer to the same parts throughout the various views. The drawings are not necessarily to scale, emphasis instead being placed upon illustrating the principles of the invention.

[00015] Fig. 1 is a diagrammatic top view of format of media having an identification window segment according to a first example embodiment.

[00016] Fig. 1A is a diagrammatic cross sectional side view of the media of Fig. 1 showing a first mode of fabrication thereof.

[00017] Fig. 1B is a diagrammatic cross sectional side view of the media of Fig. 1 showing a second mode of fabrication thereof.

[00018] Fig. 2 is a diagrammatic top view of format of media having an identification window segment according to a second example embodiment.

[00019] Fig. 3 is a schematic view of a tape drive which utilizes the media of Fig. 1.

[00020] Fig. 4A and Fig. 4B are diagrammatic views showing two respective example output signals generated by a detector of the drive of Fig. 3 for two different respective magnetic media having identification window segments in accordance with the embodiment of Fig. 2.

[00021] Fig. 5 is a flowchart showing basic steps performed by the tape drive of Fig. 3 when utilizing the media of Fig. 1.

[00022] Fig. 6 is a flowchart showing basic steps performed by the tape drive of Fig. 3 when utilizing the media of Fig. 2.

[00023] DETAILED DESCRIPTION OF THE DRAWINGS

[00024] In the following description, for purposes of explanation and not limitation, specific details are set forth such as particular architectures, interfaces, techniques, etc. in order to provide a thorough understanding of the present invention. However, it will be apparent to those skilled in the art that the present invention may be practiced in other embodiments that depart from these specific details. In other instances, detailed descriptions of well known devices, circuits, and methods are omitted so as not to obscure the description of the present invention with unnecessary detail.

[00025] Fig. 1 illustrates an embodiment of magnetic media, i.e., magnetic tape 31, according to an embodiment of the present invention. At extreme ends thereof, magnetic tape 31 has leader portions 3101 and 3102. When magnetic tape 31 is housed in a cartridge, the leader portions 3101 and 3102 are typically respectively secured to supply and take-up reels of the cartridge. Adjacent leader 3101 is a cleaning segment 3104 of magnetic tape 31. The cleaning segment 3104 has a constituency which, when in contact with a transducing element or head of a tape drive, tends to remove debris or

dust from the head. The magnetic tape 31 also has a magnetic recording/reproduction segment 3106 on which information is magnetically transduced by the head(s). In the illustrated embodiment, the information is transduced in helical stripes in magnetic recording/reproduction segment 3106.

[00026] Situated between cleaning segment 3104 and magnetic recording/reproduction segment 3106 is identification window segment 3108. The identification window segment 3108 has an electromagnetic transmissiveness which preferably differs from the magnetic recording/reproducing segment 3016 and the cleaning segment 3104. In the illustrated embodiment, the identification window segment 3108 is relatively transparent to a predetermined wavelength range (e.g., infrared energy) while the magnetic recording/reproducing segment and the cleaning segment are opaque to the same predetermined wavelength range.

[00027] Identification window segment 3018 has a dimension chosen to provide a predetermined media or cartridge signature when the media is transported at a selected linear velocity. The dimension is the length dimension L (see Fig. 1), i.e., the dimension in the direction of tape transport. This signature can be used to distinguish between characteristics of different tapes and/or cartridges, such as (for example) tape length, tape thickness, cartridge intended applications, and so forth.

[00028] In one embodiment, the cleaning segment 3104 is about two meters long. Whereas a butt joint is typically formed by the splicing of magnetic tape to a leader or to a cleaning segment, in the embodiment of Fig. 1 the identification window segment 3108 is spliced between cleaning segment 3104 and magnetic recording/reproduction segment 3106. Thus, in the embodiment of Fig. 1, an identification window splice of length L is formed. The length L of identification window segment 3108 can be varied to provide different tape/cartridge signatures. As explained hereinafter, when used in conjunction with a detector (e.g., optical detector), a unique pulse is generated in relation to the length L as the identification window segment 3108 is transported past the detector. The length L can be set differently for different tapes/cartridges in order to signify selected characteristics of the tape/cartridge.

[00029] The tape 31 with identification window segment 3108 can be fabricated in various ways, two of which are illustrated in Fig. 1A and Fig. 1B. In the mode Fig. 1A,

identification window segment 3108A is formed by splicing a third piece of tape (a transparent window tape 3120) between two other pieces of tape, i.e., pieces 3122 and 3124. Unlike transparent window tape 3120, both pieces 3122 and 3124 have relative opaque coatings 3122C and 3124C, respectively. The pieces 3122 and 3124 thus respectively form the cleaning segment 3104A and the magnetic recording/reproducing segment 3106A. Splicing tapes 3130 bridge the butt joints beneath transparent window tape 3120 and piece 3122 on the one side of piece 3120 and beneath transparent window tape 3120 and piece 3124 on the other side of piece 3120.

[00030] In the mode of Fig. 1B, two pieces of tape 3140 and 3142 are joined at a butt joint by splicing tape 3144. The identification window segment 3108B is formed by removing coating 3146 from either piece 3140 or piece 3142 for a length L. It should be understood that conversely the coating could instead be removed over the portion of tape piece 3142 at the butt joint with tape piece 3140.

[00031] Thus, as illustrated by Fig. 1A and Fig. 1B, the identification window 3108 can be made by splicing in a segment of transmissive polymeric material between two other tapes (see Fig. 1A) or provided in an uncoated (or coating removed) segment (such as occurs that the juncture of two tape pieces as shown in Fig. 1B).

[00032] In the example embodiment of magnetic media 31 shown in Fig. 1, the electromagnetic transmissiveness of identification window segment 3108 differs from that of the adjacent segments, e.g., recording/reproducing segment 3016 and cleaning sent 3104. It is not required of the identification window segment 3108 of the Fig. 1 embodiment that the electromagnetic transmissiveness necessarily be constant over the entire length L of identification window segment 3108, although it wall may be.

[00033] In the example embodiment of magnetic media 31 shown in Fig. 2, the degree of electromagnetic transmissiveness of identification window segment 3108' varies over at least some, and preferably over all, of the length L. In fact, the electromagnetic transmissiveness varies in a manner chosen to provide a predetermined media or cartridge signature when the media is transported at a selected linear velocity. Such variation in degree of electromagnetic transmissiveness for identification window segment 3108' is depicted by the waveform symbol 3109' in Fig. 2.

[00034] It should be understood that magnetic media 31 in accordance with the second embodiment can also be fabricated by various techniques, such as those illustrated in Fig. 1A and Fig. 1B.

[00035] Fig. 3 depicts an illustrative tape drive 30 in which the tape 31 of the present invention can be employed. While the particular tape drive 30 shown in Fig. 3 and discussed herein is a helical scan tape drive, it will be appreciated that the media of the present invention is useable with, and that the invention also concerns, other types of tape drives such as longitudinal or serpentine tape drives.

[00036] Fig. 3 shows a SCSI bus 20 which connects a host computer 22 and a first embodiment of a SCSI target storage device, particularly tape drive 30. In the illustrated embodiment, tape drive 30 is shown as a generic helical scan tape drive which transduces information on/from tape 31. Tape drive 30 includes a SCSI controller 32 which is connected to SCSI bus 20. Data bus 34 connects SCSI controller 32 to buffer manager 36. Both SCSI controller 32 and buffer manager are connected by a bus system 40 to processor 50. Processor 50 is also connected to program memory 51 and to a data memory, particularly RAM 52.

[00037] Buffer manager 36 controls, e.g., both storage of user data in buffer memory 56 and retrieval of user data from buffer memory 56. User data is data from host 22 for recording on tape 31 or destined from tape 31 to host 22. Buffer manager 36 is also connected to formatter/encoder 60 and to deformatter/decoder 62. Formatter/encoder 60 and deformatter/decoder 62 are, in turn, respectively connected to write channel 70 and read channel 72. Write channel 70 is connected via write amplifier 74 to one or more recording element(s) or write head(s) 80; read channel is connected via read amplifier 76 to one or more read element(s) or read head(s) 82.

[00038] Those skilled in the art will appreciate that write channel 70 includes various circuits and elements including a RLL modulator, a parallel-to-serial converter, and write current modulator. Similarly, the person skilled in the art understands that read channel 72 includes a data pattern and clock recovery circuitry, a serial-to-parallel converter, and, an RLL demodulator. These and other aspects of tape drive 30, including servoing, error correction, are not necessary for an understanding of the invention and accordingly are not specifically described herein.

[00039] Write head(s) 80 and read head(s) 82 are situated on a peripheral surface of rotating drum 84. Tape 31 is wrapped around drum 84 such that head(s) 80 and 82 follow helical stripes 86 on tape 31 as tape 31 is transported in a direction indicated by arrow 87 from a supply reel 90 to a take-up reel 92. Supply reel 90 and take-up reel 92 are typically housed in an unillustrated cartridge or cassette from which tape 31 is extracted into a tape path that includes wrapping around drum 84.

[00040] The present invention is useful not only with numerous types of tape drives, but even numerous types of tape drives within the helical scan family. For example, in one type of tape drive, tape 31 is transported by an unillustrated capstan which is rotated by a capstan motor. The drum has one write head and one read head, mounted 180 degrees apart on the periphery of the drum. In this type of tape drive, the capstan motor is controlled by transport controller 98, which ultimately is governed by processor 50. An example of this first type of tape drive is the EXB-8200 model tape drive manufactured by Exabyte Corporation, and which is illustrated e.g., in U.S. Patent 4,843,495; U.S. Patent 4,845,577; and U.S. Patent 5,050,018, all of which are incorporated herein by reference.

[00041] A second type of tape drive with which the invention is useful is the Mammoth tape drive manufactured by Exabyte Corporation, and which is illustrated e.g., in U.S. Patent 5,602,694, incorporated herein by reference. In this second type of type drive, two write heads and two read heads are mounted on the drum. A supply reel 90 and take-up reel 92 are driven by respective reel motors 94 and 96 to transport tape 31 in the direction 87. Reel motors 94 and 96 are driven by transport controller 98, which ultimately is governed by processor 50. Operation and control of the tape transport mechanism of this second type of tape drive including reel motors 94 and 96 is understood by the person skilled in the art with reference, for example, to United States Patent Application SN 08/337,620 for METHOD AND APPARATUS FOR CONTROLLING MEDIA LINEAR SPEED IN A HELICAL SCAN RECORDER, filed November 10, 1994 and incorporated herein by reference.

[00042] In accordance with the present invention, as shown in Fig. 3 tape drive 30 also includes a detector assembly 100. The detector assembly 100 is positioned to direct a ray or beam of electromagnetic energy through magnetic tape 31. In this regard, detector assembly 100 includes an emitter (e.g., diode) positioned on one side of

magnetic tape 31, and a detector positioned on an opposite side of magnetic tape 31 as shown in Fig. 3. The emitter emits electromagnetic energy of a predetermined wavelength (e.g., infrared). The electromagnetic energy emitted by the emitter is not transmitted through cleaning segment 3104 and magnetic recording/reproduction segment 3106, but is transmitted through identification window segment 3108 when the identification window segment 3108 is transported past the fixed location of detector assembly 100.

[00043] Thus, as magnetic tape 31 is transported in the tape path of tape drive 30, any movement of identification window segment 3108 past detector assembly 100 will permit the beam of the emitted light to be incident on the detector of detector assembly 100, resulting in a voltage response which is proportional to the amount of energy incident on the detector. The detector then generates a signal or pulse having a pulse width W related to the effective length L of identification window segment 3108 and the velocity of tape transport. In fact, the pulse width W is inversely proportional to the velocity of tape linear transport and proportional to the effective length L of identification window segment 3108.

[00044] The signal generated by detector assembly 100 is conditioned if necessary and applied to processor 50 (see Fig. 3). The processor 50 is programmed or otherwise preset to compare the signal, and thus the signature of the tape or cartridge, to one or more stored templates or stored signature values. These stored templates or stored signature values can be stored in a register of processor 50, or in RAM 52, for example. Upon matching of the signal (signature) from detector assembly 100 with a known one of the stored templates or signature values, the processor 50 can ascertain the identity or type of tape/cartridge which has been loaded into tape drive 30.

[00045] For the magnetic tape of the embodiment of Fig. 1, detector assembly 100 must be able to ascertain that the electromagnetic transmissiveness of identification window segment 3108 differs from that of adjacent segments for a length L which is characteristic of the tape or cartridge. In this case, what matters is that the output signal of the detector assembly 100 exceed a certain threshold in order for processor 50 to distinguish the electromagnetic transmissiveness of identification window segment 3108 from that of the adjacent segments. The pulse width of the output signal (above

the threshold) from detector assembly 100 is thus related to the effective length L of identification window segment 3108.

[00046] In an embodiment of a tape drive that utilizes the magnetic media of Fig. 2, the processor 50 not only notices that the output signal of detector assembly 100 exceeds the threshold, but also tracks the varying magnitude of the output signal of detector assembly 100. The varying magnitude of the output signal of detector assembly 100 is caused by the corresponding variance in electromagnetic transmissiveness of identification window segment 3108 along at least a portion of its length. For example, Fig. 4A and Fig. 4B show differing output signals of detector assembly 100 for two different types of cartridges or cassettes. The Fig. 4A output signal remains high (e.g., at an output voltage V_8) for a predetermined time t_1 interval, then falls abruptly to an intermediate value (e.g., at an output voltage V_4) for a predetermined time interval t_2, then rises again to the high value (e.g., V_8) for the predetermined time interval t_3 before falling below threshold V_T. The Fig. 4B output signal for identification window segment 3108, by contrast, rises to an intermediate value (e.g., at an output voltage V_4) for a predetermined time t_4, then rises to the high value (e.g., V_8) for a predetermined time interval t_5 before falling below threshold V_T. The waveforms of Fig. 4A and Fig. 4B, as well as the values V and time intervals t thereof, are in accordance with electromagnetic transmissiveness of example media, it being understood that other waveforms and values result from other media.

[00047] The values of the output signal of detector assembly 100 for the media of the second embodiment of Fig. 2 are appropriately processed, e.g., filtered and digitized, so that the processor 50 can obtain digital readings thereof. The digital values are stored , e.g., in a memory such as a sample moving buffer, which memory at any instant has values for the current waveform over a window or time base. The current waveforms are compared to stored waveform values or template for various cartridge or cassette tapes (stored in a register of processor 50 or other memory such as RAM 52). When a favorable comparison is detected by processor 50, the processor 50 knows the identity or type of the cartridge or cassette which has been loaded into the drive.

[00048] Fig. 5 shows basic steps involved in usage of the magnetic tape 31 of the media embodiment of Fig. 1. At step 5-1, the tape drive 30 detects loading of the cartridge with magnetic tape 31 into tape drive 30 in conventional manner. Thereafter,

at step 5-2, the magnetic tape 31 is transported in the direction of arrow 87 under control of transport controller 98. In one embodiment of tape drive 30 discussed above, take-up motor 96 (and optionally supply motor 94) are involved in transporting magnetic tape 31. As magnetic tape 31 is being transported, at step 5-3 processor 50 together with detector assembly 100 attempts to detect identification window segment 3108. In this regard, processor 50 commands detector assembly 100 to emit its radiant beam toward magnetic tape 31. As long as the cleaning segment 3104 is in the tape path at the point between the emitter and detector of 100, the radiant beam is blocked by the essentially opaque nature of cleaning segment 3104. However, when identification window segment 3108 passes the point of detector assembly 100 in the tape path at the time shown in Fig. 3, the detector assembly 100 outputs it signal of pulse W to processor 50. Upon detecting the signal from detector assembly 100 at step 5-3, at step 5-4 processor 50 knows that the identification window segment 3108 has been encountered. Then, using the pulse width W received from detector assembly 100, at step 5-4 the processor 50 endeavors to determine the identity of the magnetic tape 31. For example, at step 5-4 the processor 50 can use a look up table or the like to compare the pulse width W of the signal from detector assembly 100 with stored templates or values to determine the tape or cartridge type. Thereafter, as indicated by step 5-5, knowing the tape or cartridge type, processor 50 can process the magnetic tape 31 in accordance with its now know type.

[00049] For example, upon receiving a signal from detector assembly 100 indicative of the fact that the tape includes both cleaning segment 3104 and magnetic recording/reproduction segment 3106, the processor 50 can (if desired) capitalized upon the presence of the cleaning segment 3104 of the tape and perform a cleaning operation to clean heads 80, 82, etc.

[00050] If the processor 50 has not detected the identification window segment 3108 at step 5-3 within a predetermined time out period (as shown by step 5-6), the processor 50 can provide either an error message or some alternate processing that is not dependent upon knowledge of cartridge/tape type.

[00051] The currently preferred range for L is from 0.3 cm to 10 cm, and currently is more preferably 2.7 cm for identifying a cartridge suitable for use with a second version of the Exabyte® Mammoth™ tape drive.

[00052] Fig. 6 shows basic steps involved in usage of the media of the embodiment of Fig. 2. The steps of Fig. 6 are essentially the same as those of Fig. 5, with one exception being step 6-3. When utilizing the media of the embodiment of Fig. 2, upon receiving the threshold-exceeding signal from detector assembly 100 at step 6-3 the processor 50 analyzes the changing amplitude of the signal (e.g., relative to the threshold value V_T as shown in Fig. 4A and Fig. 4B), the changing amplitude being indicative of the varying degree of electromagnetic transmissiveness of the tape. Then, by finding a stored waveform or waveform template which matches or best approximates a waveform having the changing amplitude at the output signal of detector 100 (as reflected by the data stored in the sample buffer), at step 6-4 processor 50 determines the identity of the media/cassette. Thereafter, as indicated by step 6-5, processor 50 can process the cassette in accordance with its now known type.

[00053] The identification window segment 3108 thus becomes the signature of the tape or cartridge. This signature can be used to distinguish between various characteristics, e.g., tape length, tape type, tape thickness, and cartridge intended application, for example. For the embodiment of Fig. 1, the number of unique signatures is limited only by the length L of identification window segment 3108 and the ability of tape drive 30 to resolve a specific length. Manufacturing tolerances and the ability of detector assembly 100 (together with processor 50) to resolve time differences influence the ability to resolve differences in the value of L for identification window segment 3108. Advantageously, this resolution is an improvement over prior art techniques of attempting to recognized a number of holes punched in a tape, or printed lines on a tape, or metalized patterns or holes in a cartridge housing. Even greater capability is provided by the media of the embodiment of Fig. 2.

[00054] The identification window segment 3108 also becomes a point of demarcation between cleaning segment 3104 and magnetic recording/reproduction segment 3106. For instance, placing the identification window segment 3108 between cleaning segment 3104 and magnetic recording/reproduction segment 3106 performs at least two functions. A first function is identifying the tape/cartridge according to type, e.g., for example a type that has both a cleaning component and a magnetic recording/reproduction component. A second function is marking the beginning or end of a section within the cartridge and thereby creates a load point for the cartridge. In

this regard, the identification window segment 3108 can be used at either the end of tape or the beginning of tape ends of a length of media.

[00055] The second embodiment of media as exemplified by Fig. 2 has a multidimensional aspect, i.e., has more than an "on" state and an "off" state. The Fig. 2 media embodiment does not depend on a single digital state, but rather by varying transmissiveness which can provide more information in multi levels of output verses time. This means that by varying the transmissiveness of the window information can be encoded by modulating the signal received by the detector. This modulation can be in the form of modulation level verses time and wavelength of transmission. The material of identification window segment 3108' can be modified by changing its reflectivity and/or its chemical composition to absorb selected wavelengths of light. This is analogous to forming a "gray" scale for detection at different levels and preset multi level comparators feeding information to a microprocessor-based lookup table or a state machine. This method could also use "color" and holographic patterns to provide control information.

[00056] While the invention has been described in connection with what is presently considered to be the most practical and preferred embodiment, it is to be understood that the invention is not to be limited to the disclosed embodiment, but on the contrary, is intended to cover various modifications and equivalent arrangements included within the spirit and scope of the appended claims.